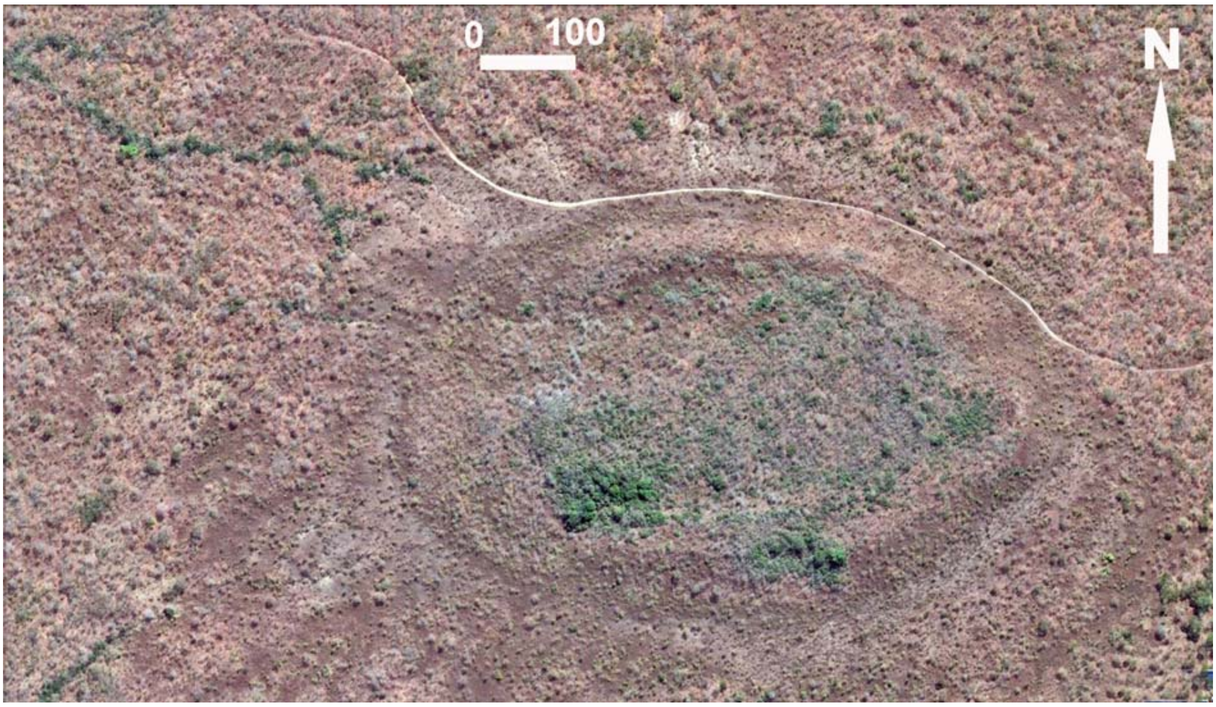
# Moçambique Palaeontology Reconnaissance November, 2012




**Mhengere Hill, Gorongosa Park, Moçambique, a palaeopan of Neogene age, the original dimensions of which would have been about 1 km E-W by 0.75 km N-S. Fossil wood was found at the northwest end of the outcrop immediately north of the vehicle track. The deposits are part of the Mazamba Formation (possibly the Inhaminga Member) supposedly of Mio-Pliocene age. Similar fossil pan deposits crop out nearby within the Inhaminga Member. Palaeopans are rare in the geological record in contrast to extant examples which are widespread in Southern Africa.**

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# Moçambique Palaeontology Reconnaissance
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**Aim**

The aim of the November, 2012, field survey to Moçambique was to assess the palaeontological potential of the Morrungulo and Gorongosa regions.

**Background**

The motivation for carrying out the palaeontological reconnaissance of Moçambique was twofold : 1) the discovery of an upper premolar of *Deinotherium bozasi* on the beach north of 7-mile rocks, south of Morrungulo (in the literature mis-spelled Morrugusu) (Harris, 1977), and 2) the report of "external sediment infilling (possible palaeontological breccia)" at Western Codzo Cave, north of Gorongosa National Park (Laumanns, 1998).

**Organisation**

The field reconnaissance was carried out in collaboration with 1) Morrungulo : David Suzman and Jane Dugard, and 2) Gorongosa : staff from the Scientific Services of the Gorongosa National Park.

**Participant from France**

Dr Martin PICKFORD, Muséum National d'Histoire Naturelle, Paris,

**Field Schedule**

1 November : Drive Johannesburg - Moputo.
2 November : Drive to Morrungulo.
3-4 November : Prospecting for fossils along the beach south of Morrungulo.
5 November : Drive to Pagoda.
6 November : To Gorongosa Park headquarters at Chitengo.
7 November : Survey of the southern parts of the Gorongosa Park and the hotsprings at Maria Bué accompanied by Alan Short.
8 November : Survey of the area east of the Urema River, Mhengere Hill and Muaredzi Gorge south of the hill, accompanied by Alan Short, Luis Matonga, Ilze Wagenaar, Jeff Trollip and a park ranger.
9 November : Start writing field report.
10 November : Drive to Vilanculo and then on toXai-Xai and Johannesburg the next day.

**Presentation**

This field report covers two areas:- 1) the coast near Massinga, and 2) the Gorongosa National Park. Each part will be discussed separately.

**Part 1 – Coastal Moçambique**

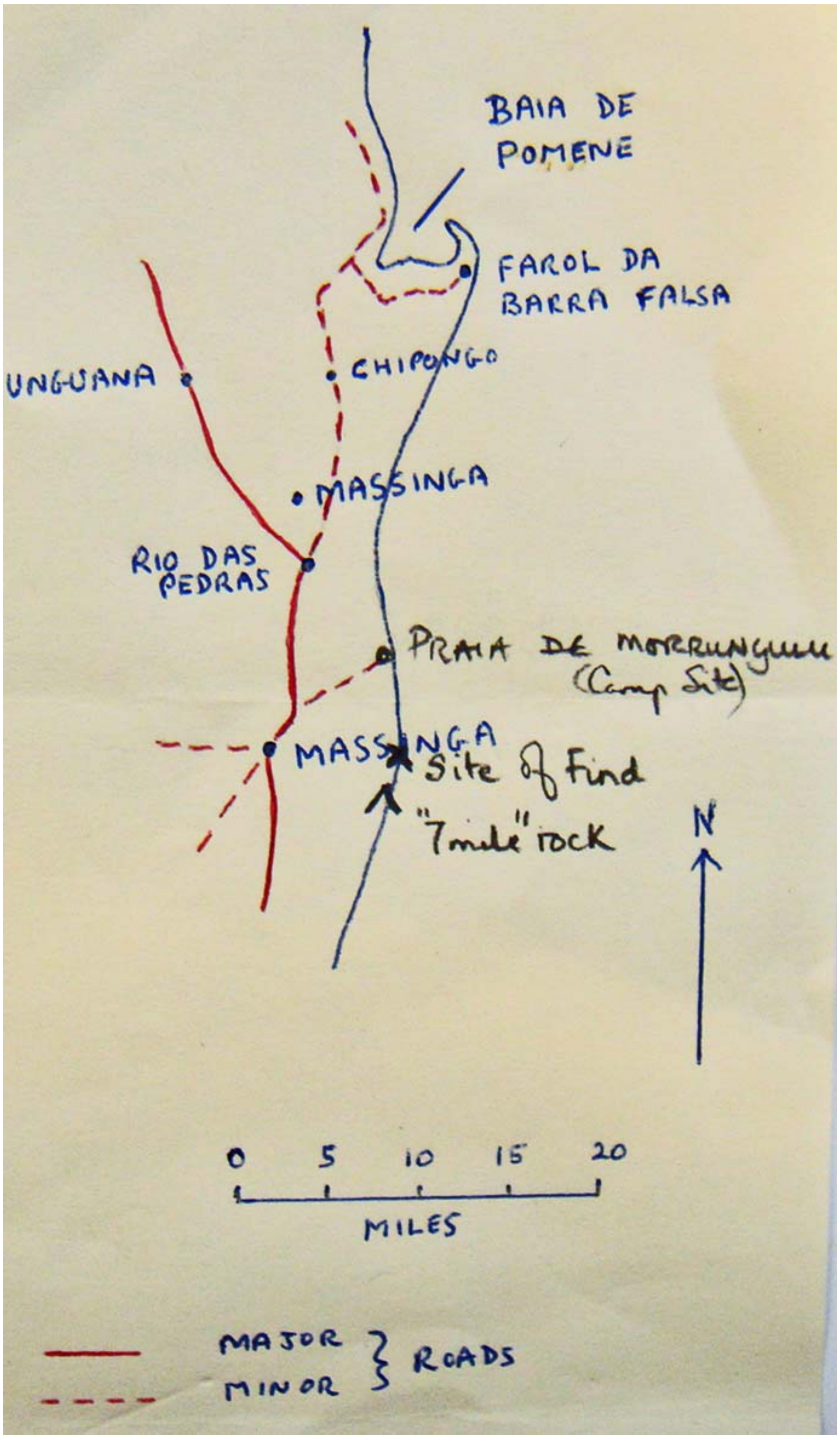


**Figure 1**. Sketch map showing the approximate position of a site on the Praia de Morrungulo, Moçambique, which yielded an upper premolar of *Deinotherium bozasi*. (Map by Dr A. Gentry, modified by Colin Hayes, the finder of the tooth, 1974).

**Figure 2**. NHML without number, upper left P4, *Deinotherium bozasi*, from Morrungulo Beach, Moçambique, described by Harris, 1977.

**Results**

The field survey of Morrungulo Beach revealed no signs of mammalian fossils, but there are important quantities of marine fossils in the areas locally known as “rocks” and “fingers” and there are abundant fossils (coral, bivalves, gastropods, serpulids) loose on the sandy beaches. At various places along the beach there are concentrations of pebbles of green-grey sandy siltstone which appear to represent deltaic deposits laid down by rivers that formerly flowed into the sea in the vicinity. There are no outcrops of this rock on the beach, so it is inferred that these pebbles are being eroded from outcrops beneath the sea, and that they are washed up with other debris such as chunks of fossil coral, *Tridachna* shells and gastropods.

**Figure 3**. Outcrop of fossiliferous marine limestones on the beach south of Morrungulo, known locally as the "Fingers". The limestone is overlain by red slightly indurated dune sand, which is overlain by white dune sand

Tour operators in the region report finding subfossil human remains in red sand dune deposits. My examination of these deposits showed the presence of pottery and shell middens.


**Figure 4**. The Morrungulo and Rio das Pedras localities north of Inhambane, Moçambique.

A deposit of travertine near the swamp at Rio das Pedras contains abundant fossil plant and invertebrate remains. The molluscs comprise both freshwater and land snails, the fauna indicating a late Pleistocene age.

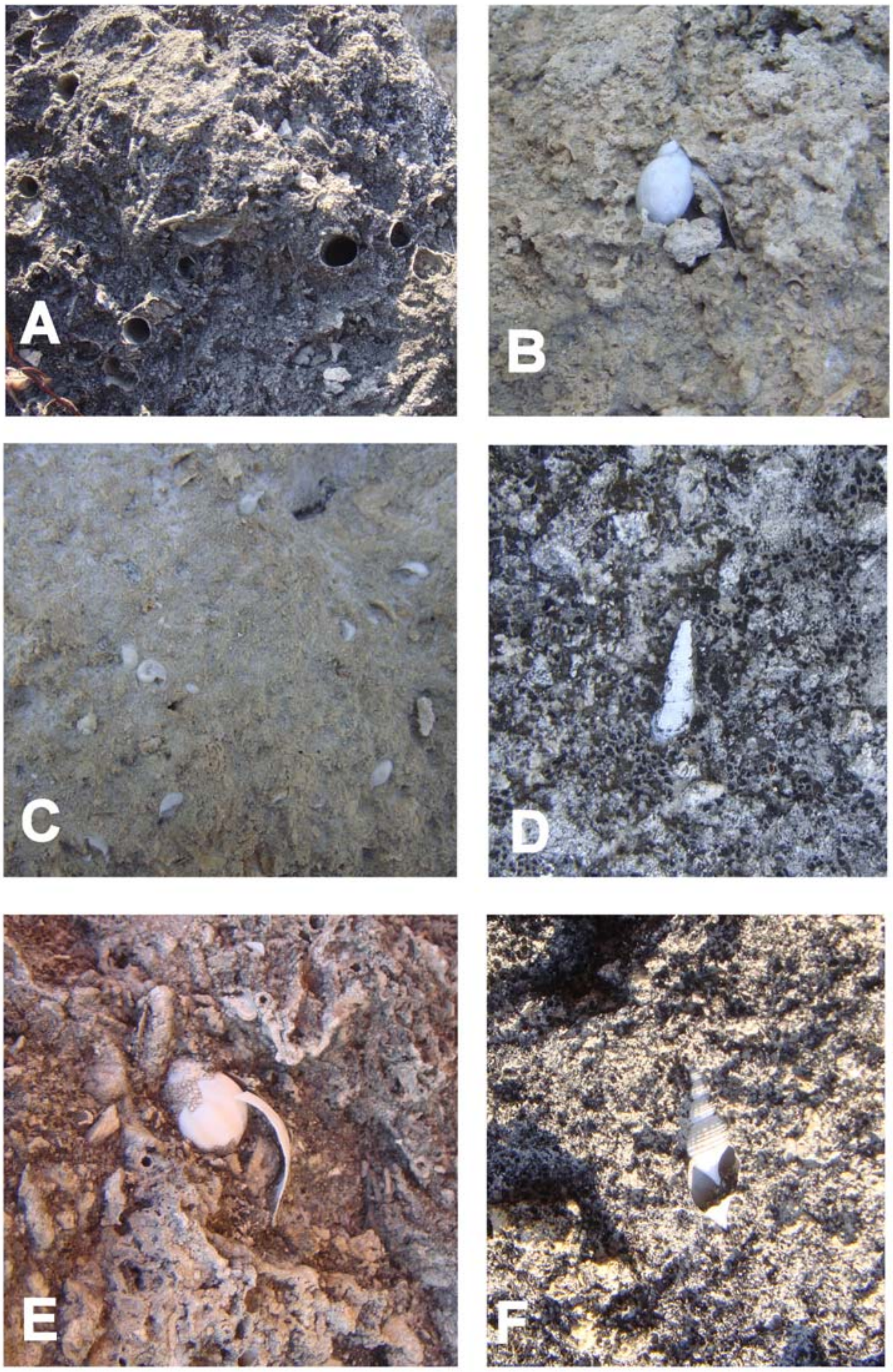


**Figure 5**. Fossil plants and gastropods in travertine at Rio das Pedras, Moçambique. A) reed stems, B) *Lymnaea*/*Physa*, C) planorbids and lymnaeids, D) *Melanoides tuberculata*, E), *Achatina*, F) *Melanoides tuberculata*

At Vilanculo beach there are richly fossiliferous littoral marine deposits containing molluscs and fossil wood. Some of the molluscs are exceptionally well preserved. At Sunset Beach Resort, Chidenguele, the shelfing rocky beach contains abundant marine faunal elements, and the overlying white dunes contain pottery and shell middens which possibly warrant further research.

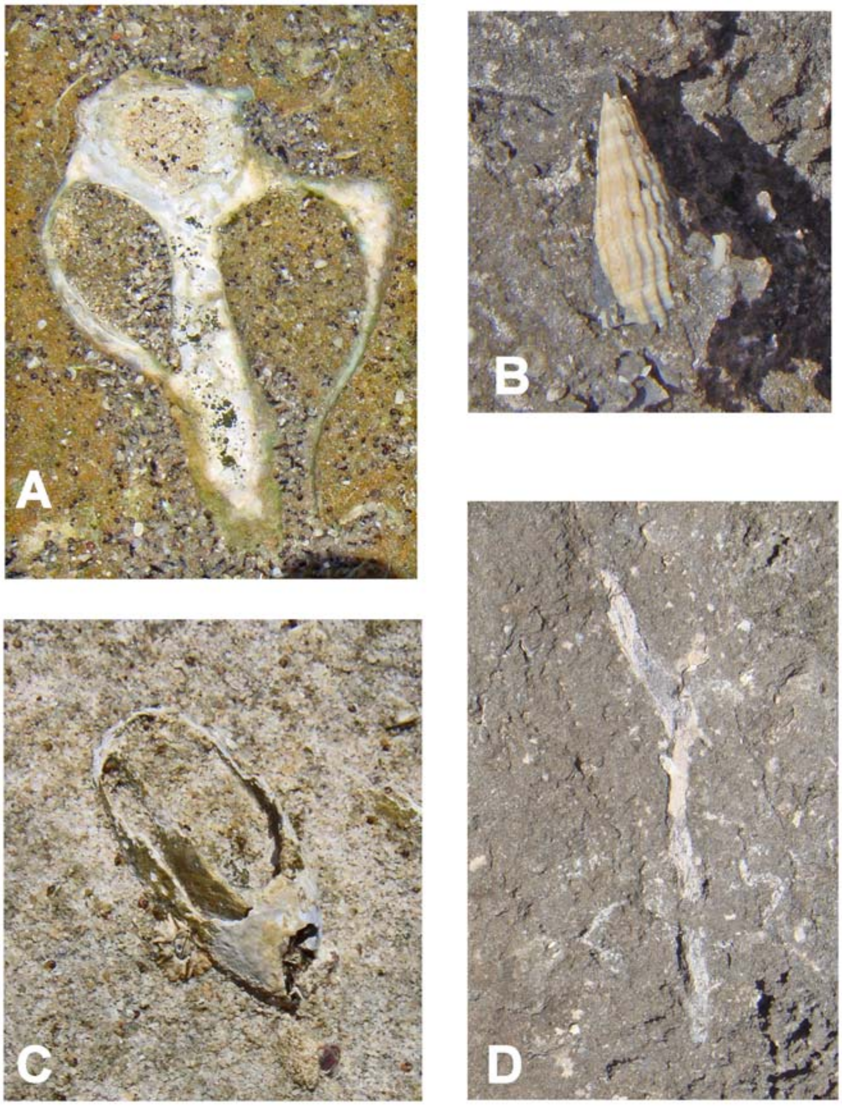


**Figure 6**. Fossil gastropods and plant stems in sandy marine limestone at Vilanculo, Moçambique.

**Part 2 – Gorongosa National Park**

The Gorongosa survey was hampered by the difficulty of access to the potentially fossiliferous cave deposits, so fewer sites were visited than originally envisaged. Nevertheless calcified fossil wood was found associated with supposedly Mio-Pliocene palaeopan deposits northwest of Mhengere Hill, and a fossilised millipede was found in eroded speleothem in the Muaredzi Gorge south of Mhengere Hill. In addition, the Eocene limestones in which the caves formed, are rich in marine invertebrates (bivalves, gastropods, nummulites, coral).

Pottery and subfossil bones were observed at several points in the Urema Floodplain. Some of these occurrences are recent, but some which are exposed in shallow gullies are possibly of

Iron Age as they appear to be buried beneath a metre or so of clayey sands (there was insufficient time to do a control sondage to verify the context of the pottery). Subfossil hippo remains were found in the dark clay of the floodplain.

**Table 1**. GPS co-ordinates of fossiliferous and geological localities in Moçambique plotted during the November 2012 reconnaissance.

| Locality | Latitude | Longitude | Observation |
|---|---|---|---|
| **Morrungulo area** | | | |
| Rocks 1 south of Morrungulo | 23°16’29.6"S | 35°29’36.6"E | Molluscs in marine limestone |
| Rocks 2 south of Morrungulo | 23°16’57.5"S | 35°29’38.6"E | Molluscs in marine limestone |
| Deinothere site (transposed from ms map) | 23°19’02.0"S | 35°29’21.5"E | Archive plot of deinothere tooth |
| Rio das Pedras | 23°11’56.0"S | 35°23’03.2"E | Plant and molluscs in travertine |
| **Gorongosa** | | | |
| Urema Crossing | 18°56’45.0”S | 34°32’33.1”E | Place to cross the Urema River |
| Mhengere Fossil wood site | 18°56’02.0”S | 34°36’50.6"E | Fossil wood associated with palaeopan |
| Travertine in Limestone Gorge | 18°57’16.8"S | 34°36’47.1"E | Eroded speleothem in lateral gallery of the gorge |
| Western Codzo Cave | 18°32’59"S | 31°25'49.8"E | Cave in Eocene limestone |
| Lanistes site Urema Flood Plain | 18°54’42.1"S | 34°32’49.5"E | Large specimens of recent *Lanistes ovum* |
| Net sinker site Urema Flood Plain | 18°54’38.7"S | 34°32’40.3"E | Faieance net sinkers |

## Palaeontology at Gorongosa

### <u>Geological Background</u>

The Gorongosa region has several geological settings that are conducive to the preservation of fossils. The Sena and Grudja formations, supposedly of Cretaceous age, contain marine fossils. Eocene marine limestones cropping out in the Cheringoma Plateau east of the rift valley (the Cheringoma Formation) contains abundant marine faunal remains (coral, gastropods, bivalves, nummulites). Conglomeratic sands that unconformably overlie the limestones, attributed to the Mazamba Formation are associated with chert deposits and quartzitic limestone, said to be of Miocene or Pliocene age. The Eocene Limestones host caves and other karst features which are known to contain speleothems and cave breccias. In other parts of Africa, such karst infillings are often fossiliferous. Fourthly, the sediments infilling the Urema Rift are likely to be fossiliferous, but the fact that few if any pre-Pleistocene strata crop out in the region means that fossils are inaccessible under an unknown thickness of alluvium and colluvium.

The stratigraphy and fossil potential of the Cretaceous and post-Cretaceous deposits of the Gorongosa area, Moçambique is summarised in table 1.

**Table 1**. Cretaceous and post-Cretaceous stratigraphy of the Gorongosa area, Moçambique and the fossil potential of the deposits.

| | | | |
|---|---|---|---|
| Recent | Un-named unit | Talus, alluvium and colluvial fans | Subfossils common |
| Pleistocene | Un-named unit | Sandy eluvium and sandy-clay alluvium | Could be fossiliferous |
| Mio-Pleistocene | Un-named units | Speleothems and karst fill breccias | Fossiliferous |
| Mio-Pliocene | Mazamba Formation | Inhaminga quartzitic and conglomeratic sandstone | First fossils found during the 2012 survey |
| Mio-Pliocene | Mazamba Formation | Chert | Potential for fossils |
| Mio-Pliocene | Mazamba Formation | Red sandstone quartzitic limestone | Fossil gastropods, bivalves |
| Mio-Pliocene | Un-named unit | Nepheline Basalt near Inhaminga | Slight potential for fossils |
| Eocene | Cheringoma Formation | Nummulitic limestone, glauconitic sandstone base | Richly fossiliferous marine fauna |
| Cretaceous | Grudja Formation | Calcareous and glaconitic sandstone | Richly fossiliferous marine fauna |
| Cretaceous | Sena Formation | Arkosic sandstone (calcic-argillaceous cement) | Plant and fish remains reported |
| Cretaceous | Lupata Series | Lupata Sandstone, Quartz-breccia, Carbonatite, Trachyte | Could be fossiliferous |

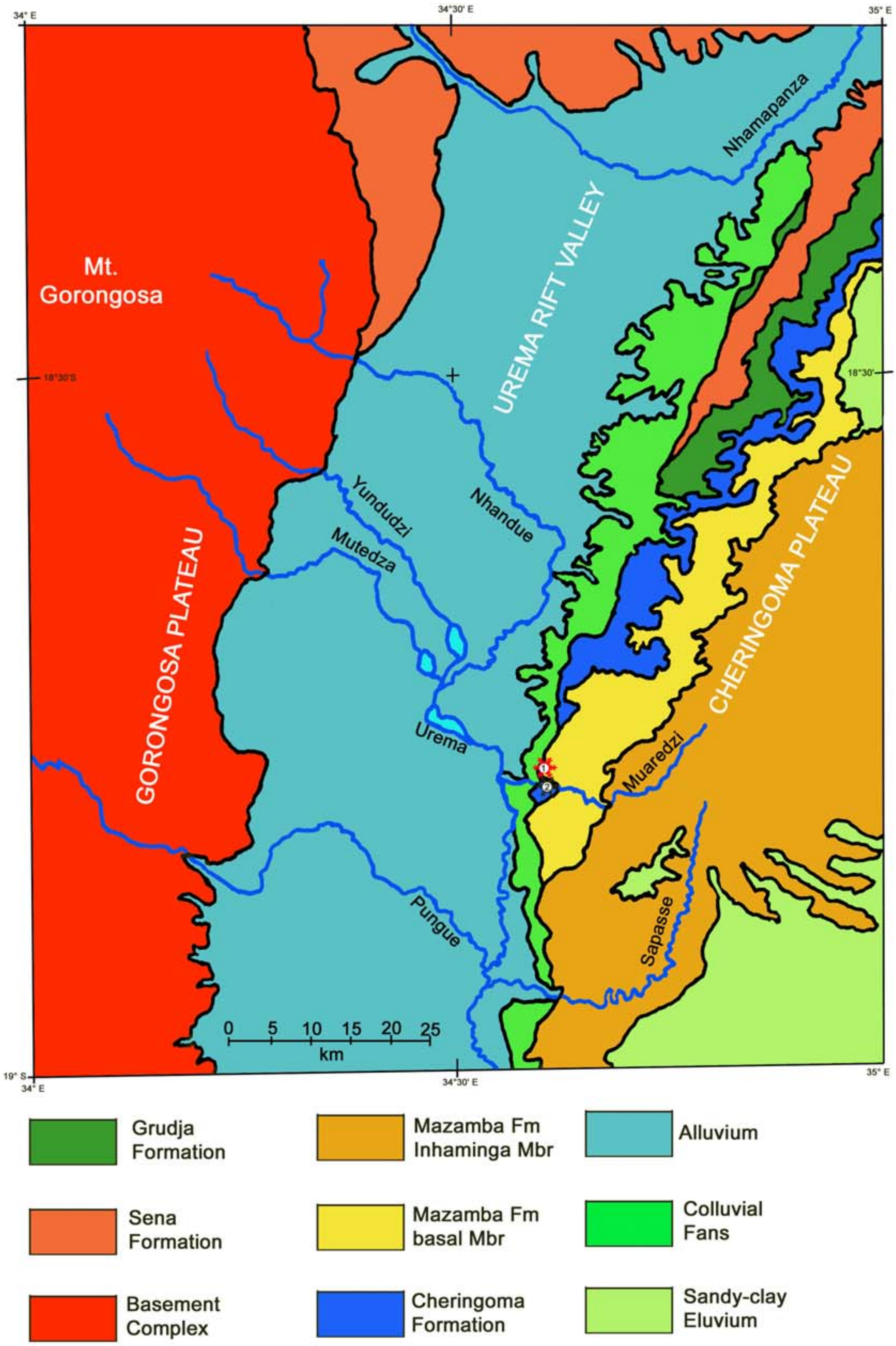


**Figure 7**. Simplified geological map of part of the Gorongosa region showing the rift valley infilled with colluvium and alluvium, flanked to the west by crystalline basement rocks, and to the east by Eocene limestones and subjacent rocks. Caves and related karst infillings occur in the limestones. 1 – Mhengere Palaeopan, 2) Muaredzi speleothem tongue. Map based on the National Directorate of Geology (2006).

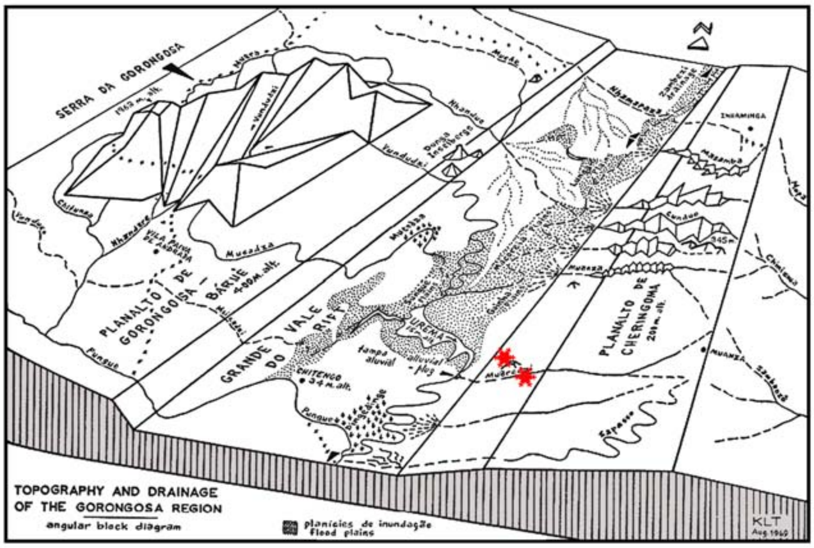


**Figure 8.** Angular block diagram of the Gorongosa region showing the main geomorphological features. Red stars are sites which yielded fossil wood and a petrified millipede. Diagram modified from Tinley, 1977.

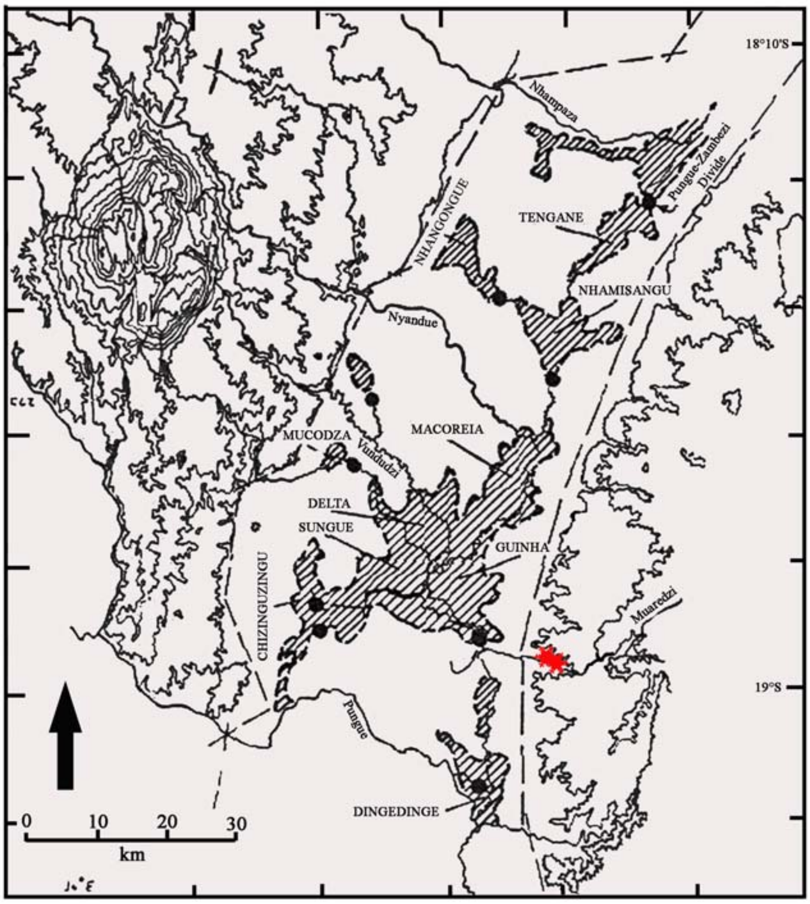


**Figure 9.** Drainage and swamps of the Gorongosa region, Moçambique. Map modified from Tinley, 1977. Red stars, fossil wood and petrified millipede.

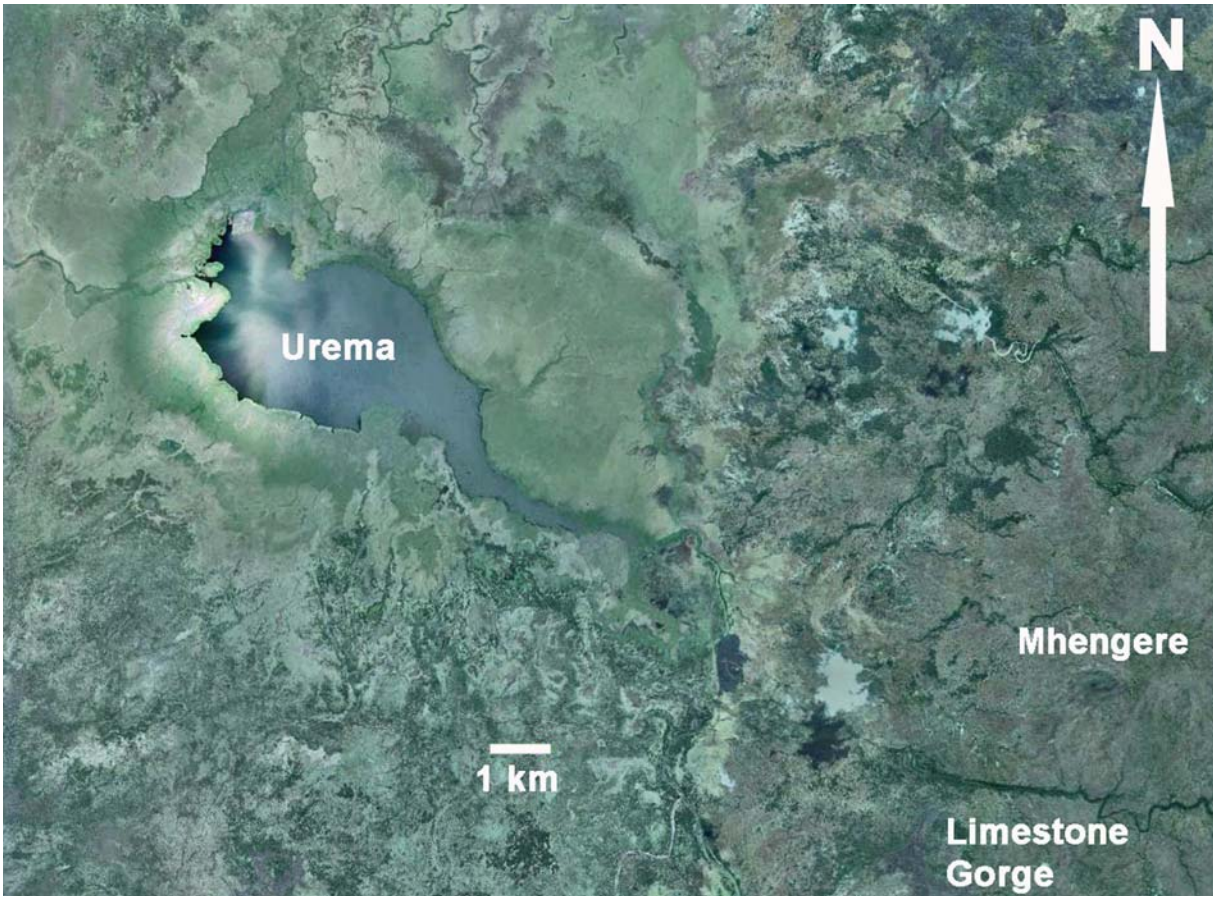


**Figure 10**. The Urema-Mhengere sector of the Gorongosa National Park, Moçambique. Google Earth image.

**Figure 11**. Fossil wood from Mhengere, Gorongosa, lateral view and section.

The fossil wood from Mhengere, which is calcified, has been examined by Dr Marion Bamford, Wits University, Johannesburg. It is angiospermous with vessels arranged in short radial multiples, the parenchyma is vasicentric and diffuse-in-aggregate, the rays are biseriate and heterocellular. There are some narrow growth rings which are discontinuous, and thus probably not annual rings. Further study is required of tangential sections, which will hopefully result in an identification of the type of tree represented. According to Dr Bamford, the wood is post-Eocene, which is not surprising considering that it was associated with a palaeopan deposit that accumulated on top of the Eocene Cheringoma Limestone. The excellent preservation of the microstructure of the fossil wood is a most encouraging sign that the conditions for fossilisation were good, which means that other kinds of fossils, notably bone and teeth ought to be preserved as well.

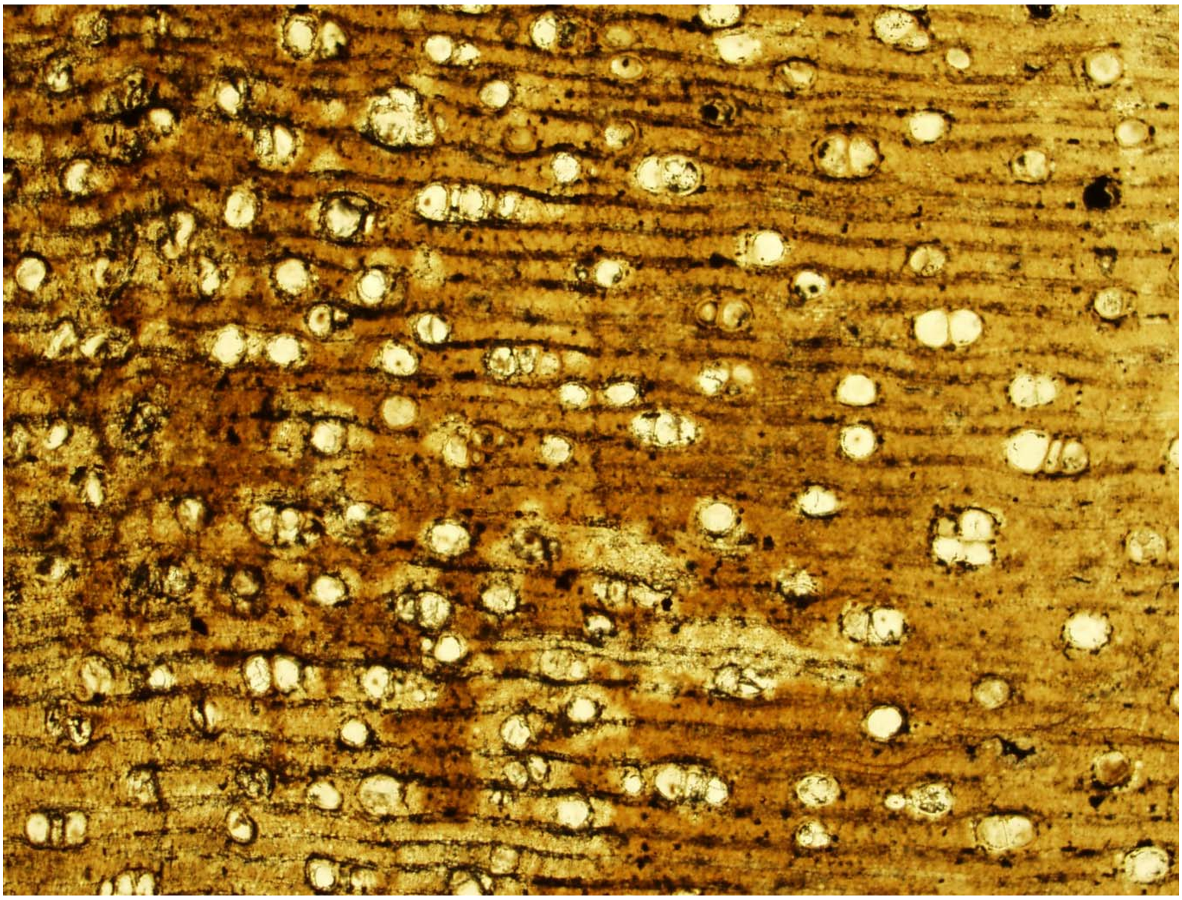

**Figure 12**. BP-16-1707, fossil wood from Mhengere, Gorongosa National Park, transverse section (x 40) showing the excellent preservation of the cellular structure.

**Figure 13**. BP-16-1707, fossil wood from Mhengere, Gorongosa National Park, radial longitudinal section (x 200) showing the dark parenchyma cells alongside the vessel (horizontal) and the heterocellular ray cells overlying the vessel (vertical).

**Figure 14**. Muaredzi limestone Gorge south of Mhengere, shows characteristic bell-shaped walls which indicate that it was formerly a cave, now missing its roof (the vertical walls above the undercut). Marine fossils in the limestone are correlated to the Eocene (ca 35 Ma).

**Figure 15**. Tongue of partly eroded ancient speleothem in a lateral gallery of the Muaredzi limestone gorge south of Mhengere Hill. This stalagmitic flowstone contains fossils, notably, a petrified millipede. A nearby outcrop yielded a crab claw, possibly of Eocene age.

**Figure 16**. Fossil millepede in ancient stalagmitic speleothem in a lateral gallery of the limestone gorge south of Mhengere Hill.

**Malacology at Gorongosa**

Land and freshwater snails are excellent ecosystem indicators. Not only do snail assemblages indicate parameters such as vegetation type, seasonality, mean annual rainfall and altitude (below or above 1200 m), but many individual snail species do as well. The health of an ecosystem can be guaged by studying the diversity of snails that occur in it, a healthy ecosystem possessing a greater diversity of snails than a degraded version of the same ecosystem.

Observations during the recce to Gorongosa reveal that it has good potential for containing a high diversity of snails (possibly up to 30 terrestrial taxa), but the very limited time spent looking for snails meant that only one freshwater snail taxon, and 8 species of land snails were observed. The specimens of the freshwater snail *Lanistes ovum* seen are among the largest that the author has observed, meaning that the Urema river is an excellent habitat for the species. Unfortunately, fishermen using nets often dredge up individuals of this snail, which are then discarded onto land by the fishermen. If thrown back into the water they would survive, so it is suggested that the fishermen need to be educated to replace any freshwater snails that they catch back into the river or swamp where they caught them.

The land snails at Gorongosa are typical of the lowland semi-arid (nyika) belt of Eastern Africa. The most frequently observed species due to its gigantic proportions is *Achatina immaculata*, which can reach 10 cm in length. *Tropidophora* is common, as is *Trochonanina*. Rarer are *Pseudoglessula*, *Rhachistia*, *Trachycystis* and the rapacious streptaxid snails, *Gulella* and *Pseudogonaxis*. The record of *Pseudogonaxis* from Gorongosa is one of the most southerly known, this genus being unknown from Natal further south (Herbert & Kilburn, 2004). It is common further north as far as Kenya and Uganda.

The studies of stable isotopes of oxygen and carbon of molluscan shells is becoming increasingly common as they reveal interesting information about environmental conditions during the growth of the individuals (seasonality, temperature, vegetation cover). The large species from Gorongosa appear to be ideal for such studies

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**Figure 17**. *Lanistes ovum*, a sinistral freshwater ampullariid mollusc from the Urema River, Gorongosa Park, Moçambique (scale 1 cm). Specimens from Urema are particularly large.

**Figure 18**. *Achatina immaculata*, a giant achatinid land snail from the Gorongosa Park, Moçambique (scale 10 cm).

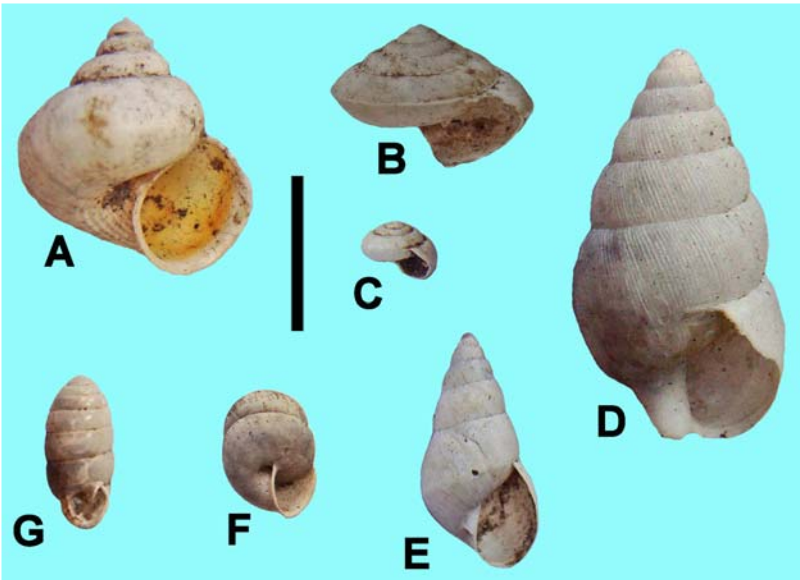


**Figure 19**. Landsnails from the Gorongosa Park Miombo Woodland ecosystem, on limestone substrate, Moçambique. A) *Tropidophora*, B) *Trochonanina mozambiquensis*, C) *Trachycystis*, D) *Pseudoglessula*, E) *Rhachistia*, F) *Pseudogonaxis*, G) *Gulella* (scale bar : 1 cm).

**Osteology at Gorongosa**

Abundant vertebrate skeletons were observed in the Gorongosa Park, notably in the floodplain of the Urema. It would be exceptionally useful for osteological science to collect as many of the skeletons as possible, not just the skulls, but all the bones and teeth (each individual kept in a sack or a box separate from other individuals). It is now widely recognised in palaeontological circles, and in comparative anatomy in general, that samples need to be as comprehensive and as rich as possible, in order to obtain adequate samples that demonstrate individual variation, sexual dimorphism and neontological changes (growth variables). There is no such thing as a duplicate sample in biology, so the more skeletons collected the better the collections are for research purposes.

Many of the skeletons kept in European museums are of animals that came from zoos, and they are thus provide less reliable data about variation in the species because the animals often underwent skeletal modifications due to poor or unnatural diets, diseases contacted in the zoos, and cramped living conditions, and many of the males were castrated. Provenience data of some material is absent or suspect, and one cannot rule out the possibility that some of the skeletons belong to cross-bred animals. In contrast wild animal skeletons from natural settings yield more reliable information about variation in the species because they have not experienced such unnatural environments.

There is good potential at Gorongosa for carrying out taphonomic studies on these skeletons, in order to document post-mortem changes that occur to the bones and teeth (desiccation cracking, burial diagensis etc.). It is also of interest to undertake stable isotope studies of teeth and bones of as many individuals as possible of various taxa in order to understand the relationship between bone tissue composition, enamel composition, climate, vegetation and substrate. This is a burgeoning discipline in ecological and palaeoecological sciences. For instance, hypsodont teeth of the wart hog (*Phacochoerus*) grow over several years and record changes in oxygen and carbon isotopes related to seasonality.

**Figure 20**. Bushbuck (*Tragelaphus*) skeleton at Gorongosa flood plain.

**Figure 21**. Waterbuck (*Kobus*) skeleton at Gorongosa flood plain.

**Figure 22**. Baboon skull and elephant teeth and jaw near the outlet of the Muaredzi limestone gorge south of Mhengere Hill. Such remains are of interest for osteological and stable isotope studies.

**Figure 23**. Skull of *Phacochoerus* (wart hog) from Urema Flood Plain, Gorongosa. Scales 10 cm. The bones and teeth are well preserved and are ideal material to be conserved in a holistic osteology collection (ie all the skeletal parts available are collected and kept together individual by individual without mixing different individuals together).

**Conclusions**

The main conclusion to emerge from the palaeontological reconnaissance to Moçambique is that the karst deposits associated with Eocene marine limestones appear to have good potential for yielding faunal remains of post-Eocene age. Particularly encouraging are the speleothem deposits in the Muaredzi Gorge. The region of Codzo was not visited due to difficulties of access and shortage of time, but the available information suggests that the various caves in the area would be well worth surveying for fossils.

Completely unexpected was the discovery of a palaeopan deposit in the supposedly Mio-Pliocene Mazamba Formation, which unconformably overlies the Eocene Cheringoma Limestone. A brief stop at the flank of the palaeopan deposit, known as Mhengere Hill, yielded a well preserved sample of calcified fossil wood. Today, pans are common in Southern Africa (South Africa, Namibia, Botswana, Zimbabwe, Moçambique) and some are well known for their rich archaeological records. However, to my knowledge few pans of Mio-Pliocene age have been reported in the literature, mainly in the Namib Desert (Ward, 1988). If the Mhengere deposit is confirmed to be a Miocene palaeopan, it will be of the greatest interest, not only for its fossil potential, but also for the geological insights it may yield.

It is clear that most of the rocky outcrops along the beaches in Moçambique are richly fossiliferous with marine faunas and some fossil wood. Near the coast, associated with swamps and rivers, there are travertine deposits rich in freshwater molluscs, land snails and plant remains.

The palaeontology survey, even though brief, revealed that Moçambique has excellent potential for yielding continental fossils of Cainozoic age, principally in association with karstic deposits in Eocene Marine Limestones, and fluviopaludal deposits overlying Eocene limestones. Young travertine deposits associated with swamps and rivers contain abundant fossil remains of freshwater and terrestrial fauna and flora.

**Future palaeontological action**

It is proposed that in 2013 a longer reconnaissance of the Gorongosa region be undertaken by a slightly larger team of researchers. The few days spent in the region by the author in November 2012 resulted in the discovery of two Neogene fossil sites in two radically different sedimentological settings, one in a palaeopan, the other in speleothem in a karst gallery. These discoveries indicate that the potential for the identification of additional fossil occurrences is promising, but the results do not, as yet, warrant the organisation of a long term research programme.

My current understanding of the geo-palaeontological situation has prompted me to search the literature and Google Earth images, and I have identified several additional palaeopan localities near Gorongosa which should be examined. This will take about one week. The Cheringoma karst network is widespread and will require about two weeks to assess in a preliminary way. It should be noted that the aim of the reconnaissance is to identify and assess the potential of fossiliferous localities, but not to carry out extensive excavations. The latter, if the results warrant it, will be undertaken by a long term organisation implicating researchers from France and Moçambique.

**Acknowledgements.**

I am anxious to thank the staff at Gorongosa National Park for their interest in the reconnaissance (Vasco Galante – Communications Manager; Marc Stalmans – Scientific Services Director) and for participating in the field survey (Alan Short, Jeff Trollip, Ilze Wagenaar, Luis Matonga). Tish Grant, Alberto Trinidade and Barbara Trinidade were most encouraging and positive. At Morrungulo, James Nelson, Wolfgang and Charlie provided local knowledge. Last but not least, I received an enormous amount of moral and logistic support and encouragement from Jane Dugard and David Suzman (Johannesburg). Thanks to José Braga (University of Toulouse) for organising an air ticket from Paris to Johannesburg and to Francis Duranthon (Natural History Museum, Toulouse) for discussions and information.

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